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MAPPING NORTHERN ATLANTIC COASTAL MARSHLANDS,
MARYLAND-VIRGINIA, USING ERTS IMAGERY

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Abstract

Coastal zone management decisions are dependent upon timely, accurate information such as location, size and value of major wetlands and identification of areas significantly impacted by man's activities. ERTS-1 data provides repetitive synoptic coverage for analysis of wetland ecology, detection of change, and mapping or inventory of wetland boundaries and plant communities. ERTS-1 positive transparencies of Atlantic Coastal wetlands were enlarged to different scales and mapped using a variety of methods. Results of analysis indicate: (1) mapping of wetland boundaries and vegetative communities from imagery at a scale of 1:1,000,000 is impractical because small details are difficult to illustrate; (2) mapping to a scale of 1:250,000 is practical for defining land-water interface, upper wetland boundary, gross vegetative communities, and spoil disposal/dredge and fill operations; (3) 1:125,000 enlargements provide additional information on transition zones, smaller plant communities, and drainage or mosquito ditching. Overlays may be made directly from prints.

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Introduction

The coastal marshes surrounding Chesapeake Bay and the shallow coastal bays of Maryland, Delaware, and Virginia play a major role in the maintenance of productivity in these estuaries and the adjacent shallow ocean. As human population increases in the Central Atlantic States, demands for recreational, residential, and industrial development in the coastal zone conflict directly with the world-wide need for maintenance and improvement of human food sources (shellfish, finfish) based upon aquatic ecosystems. Coastal zone management decisions are dependent upon accurate, timely information such as the location, size, and value of major wetlands and identification of areas significantly impacted or threatened by man's activities.

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ERTS-1 Data

ERTS-1 data provides repetitive synoptic coverage for analysis of wetland ecology, detection of change due to season, natural disaster, or human activity, and mapping or inventory of wetland boundaries and gross plant communities.

Multispectral data collected by the ERTS MSS system is in 4 spectral bands. Bands 4 and 5 are in the green and red regions of the visible spectrum and bands 6 and 7 are in the near infrared region of the spectrum. (For more detailed account, see Symposium paper by Anderson, R. R., Carter, V., and McGinness, J., Mapping Southern Atlantic Coastal Marshlands, South Carolina-Georgia, Using ERTS Imagery.)

Figure 1 is a map of the Chesapeake Bay area showing the location of the ERTS frames referenced in this paper. One ERTS frame is 100 nautical miles on a side and represents 10,000 square miles in area. The smaller areas outlined are two test areas examined in detail in the following pages. Area 1 (Figures 2 and 3) is a salt marsh complex located at the mouth of the Chincoteague Bay in Virginia. Area 2 (Figures 4 and 5) is a large, near-saline marsh at the mouth of the Nanticoke River in Dorchester County, Maryland. Maryland has approximately 300,000 acres of wetlands, 250,000 of which lie on the Eastern Shore, or what is commonly called the Delmarva Peninsula. Virginia has approximately 330,000 acres of wetlands, over half of which also lie on the Delmarva Peninsula.

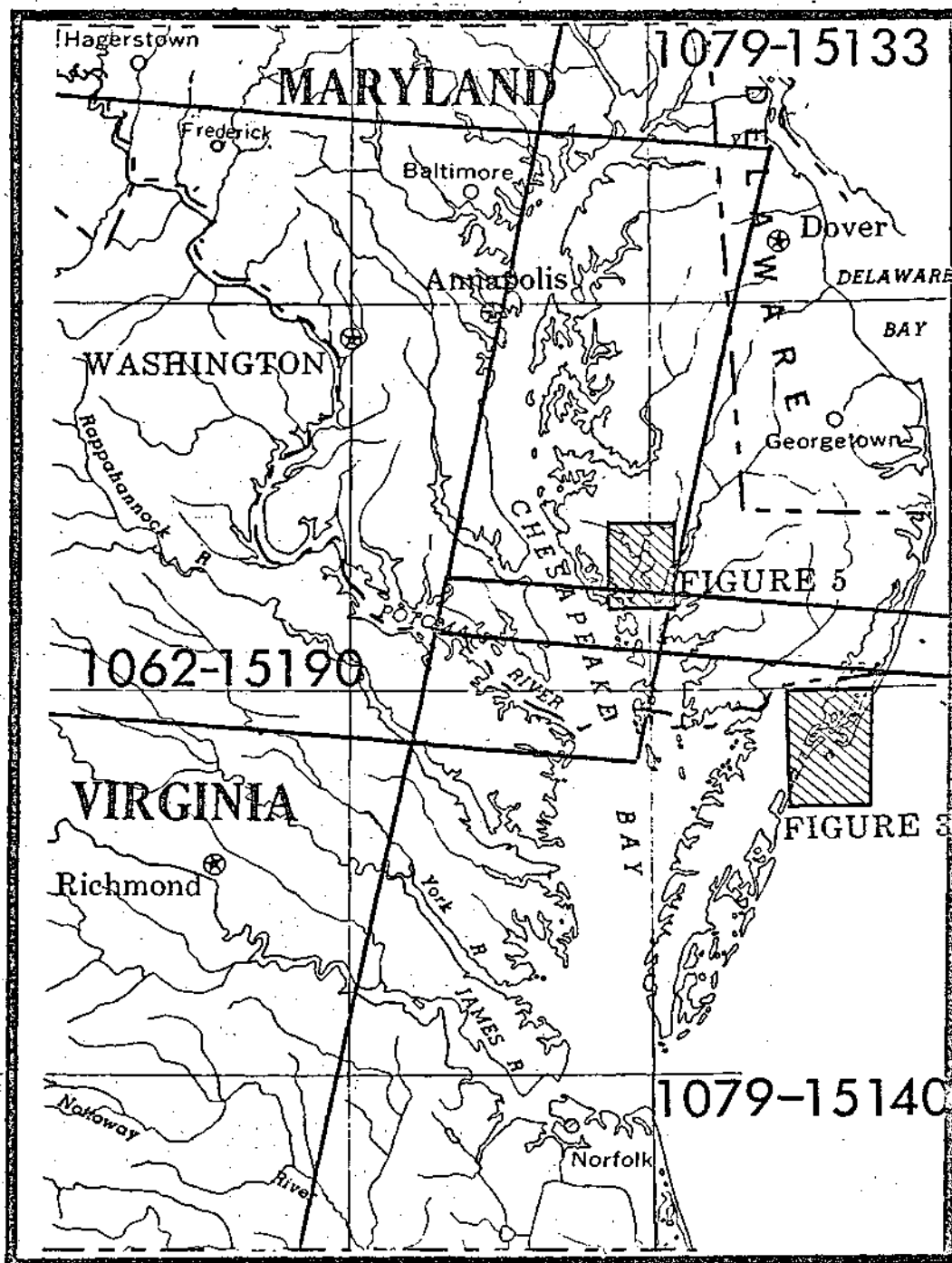


Fig. 1. Map of Chesapeake Bay area showing location of ERTS images (1079-15133, 1062-15190, 1079-15140) and smaller test areas 1 (Fig. 3 - Chincoteague marsh) and 2 (Fig. 5 - Nanticoke marsh).

ERTS positive transparencies at a scale of 1:1,000,000 as delivered from the Goddard Space Flight Center have high resolution and excellent contrast. Detail in the denser portions of the image containing coastal wetlands is somewhat difficult to utilize fully without some special processing to bring up the contrast. The marsh-water interface and the upper wetland boundary are clearly seen on MSS bands 6 and 7, with or without the use of hand magnifying equipment. Large plant associations or communities can also be identified on either MSS band 7, or on color composites made using the Diazo subtractive color technique. Most of the color composites produced by Goddard have been processed to bring out land details and are not entirely satisfactory for wetlands studies. Tree islands in the Nanticoke marsh as small as 160 meters in length and small streams larger than 16 meters in width can be detected in high contrast areas. Mapping of vegetation on wetland boundaries at this scale is, however, impractical since the many small details are impossible to illustrate.

Table 1 is a summary of the average spectral reflectances, in percent, of a number of major wetland plant species and other wetland components.

The reflectance values listed in this table are representative values, or ranges of values, chosen to illustrate the general relationship between wetlands reflectances during the growing season. Actual reflectance of salt marsh plant associations can be expected to vary depending on percentage composition of species, density, tidal inundation and season. The coastal marshes generally appear as a dark grey tone near the dense end of the scale on band 6 and 7 images, and as a dark red-grey in a color infrared simulation (color composite). This is largely because the spectral reflectance of the dominant marsh species, or species associations, on either side of the Delmarva Peninsula is generally low in bands 6 and 7 [Table 1: Spartina alterniflora (salt marsh cordgrass), Salicornia sp. (glasswort), Juncus roemarianus (needlerush)]. In bands 4 and 5, all marsh species have a low overall average reflectance and appear very dark in tone similar to dry-land vegetation. Where the coastal marshes become fresher, the spectral reflectance of the species composing these marshes is higher in the infrared region of the spectrum and the plant cover is generally denser. During the peak of the growing season, it may be difficult to determine the landward boundaries of these fresh marshes.

Table 1: Average or Range of Average Spectral Reflectance, in Percent, for Wetland Species and Components in ERTS MSS Bands 4-7

| Wetland Species or Component | MSS Band | | | |
|--|---------------|---------------|---------------|---------------|
| | 4 | 5 | 6 | 7 |
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| <u>Spartina alterniflora</u> (salt marsh cordgrass) | 3.6- 5.2 | 3.9- 5.3 | 12.7- 17.4 | 16.0- 23.5 |
| <u>Salicornia sp.</u> (glass wort) | 4.7 | 5.2 | 13.8 | 18.7 |
| <u>Spartina patens</u> (salt meadow cord grass) | 3.7- 7.1 | 4.2- 7.7 | 18.3- 27.9 | 21.4- 41.1 |
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| <u>Juncus roemarianus</u> (needlerush) | 2.4 | 3.1 | 7.5 | 10.9 |
| <u>Spartina cynosuroides</u> (giant cordgrass) | 4.2 | 3.7 | 20.9 | 28.1 |
| mudflat | 3.9- 6.0 | 4.4- 7.7 | 6.1- 11.5 | 7.0- 11.6 |
| sand | 12.9- 13.7 | 17.0- 20.0 | 22.8- 26.1 | 25.8 |
| water (turbid) | 9.5 | 10.4 | 7.8 | 4.1 |

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Wetlands Mapping from ERTS-1 Data

Use of a Bausch and Lomb Transfer Scope in combination with 1:1,000,000 scale ERTS format permits enlargement of the image and construction of maps and overlays to a scale of 1:250,000. Figure 2 is a 1:250,000 enlargement of an ERTS MSS 7 (ERTS image number 1079-15140) image of the Chincoteague salt marsh complex. Figure 3 is a 1:250,000 map of the same area showing four categories: (1) upland vegetation and beach, (2) water, (3) Spartina alterniflora/Salicornia sp. association and (4) Spartina patens/Distichlis spicata (spike grass)/Iva frutescens (marsh elder) association to be delineated. The upper/wetland boundary is



Fig. 2. 1:250,000 enlargement of Chincoteague salt marsh (1079-15140-7).

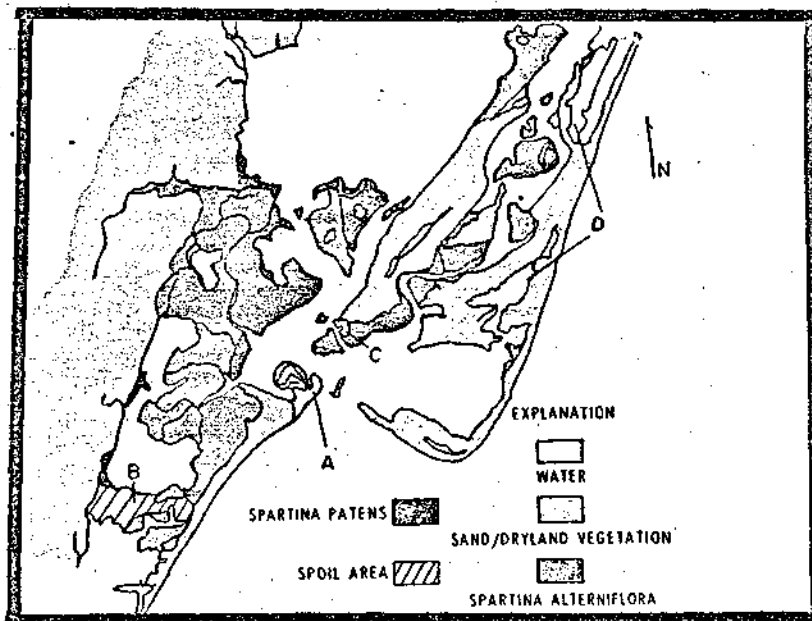
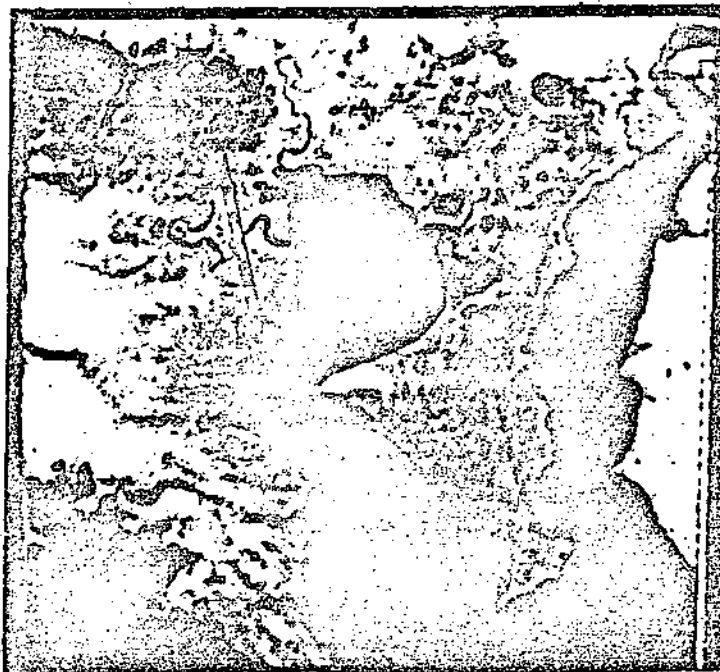


Fig. 3. 1:250,000 map of Chincoteague salt marsh. A - sand/marsh area; B - old spoil area; C - recent spoil fill; D - fresh water impoundment.

generally sharp except where broad transition zones exist. The marsh-water interface is sometimes difficult to determine in areas interlaced with numerous small tributaries or sparse patches of vegetation. Sand and marsh at the mouth of Chincoteague Bay (Figure 3: A) are not shown on the USGS 1:250,000 map published in 1966. Area C is a recent spoil fill at the tip of Chincoteague Island. Spoil areas may be easily separated from reflective vegetation by referring to bands 4 and 5 or by using a color composite since they are highly reflective in all four bands. Areas labeled D are fresh water impoundments in the Chincoteague Wildlife Refuge. The striped area (B) at the south end of the map is an area where old spoil banks are partially revegetated. It is quite distinctive in the band 7 image as a light area extending from Wallops Island to the mainland.

Figure 4 is a 1:250,000 scale enlargement of the Nanticoke marsh (MSS band 7, ERTS image 1079-15133). Species composition in this marsh is typical of a near-saline environment. The marsh area shown here is approximately 10 miles long and 5 miles wide. Figure 5 is a 1:250,000 map of the same area made by overlaying the 1:1,000,000 scale image enlarged with an overhead projector. A number of tree islands dot the marsh, the largest of which contains the small community of Elliotts' Island. The marsh vegetation includes a Juncus roemarianus/Scirpus sp. (three-square)/Spartina alterniflora association in the lower marsh areas and a high marsh community -- Spartina patens/Distichlis spicata/Iva frutescens/Baccharis halimifolia (groundsel bush) primarily located along the edges and near the single road. Toward the northern end of the marsh, the water becomes more brackish and less saline. Stands of Spartina cynosuroides (giant cordgrass) occupy the stream margins within this portion of the marsh. Isolated stands of Phragmites communis (reed) occur, but they are generally too small to be detected on the ERTS imagery. Because the signature of the dominant low marsh species, Juncus roemarianus, is close to that of water (Table 1) it is difficult to delineate the marsh-water interface within the marsh itself.

Mapping at a scale of 1:250,000 is adequate for the general delineation of large marshes and for rather gross plant species associations. Enlargement of the imagery to a scale of 1:125,000 provides additional information when processing is done to enhance the contrast in the denser part of the image. Overlays can be made directly from the prints which show the marsh-water interface and upper wetland boundary clearly. Where broad successional zones exist, these can



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Fig. 4. 1:250,000 enlargement of Nanticoke River salt marsh (1062-15190-7).

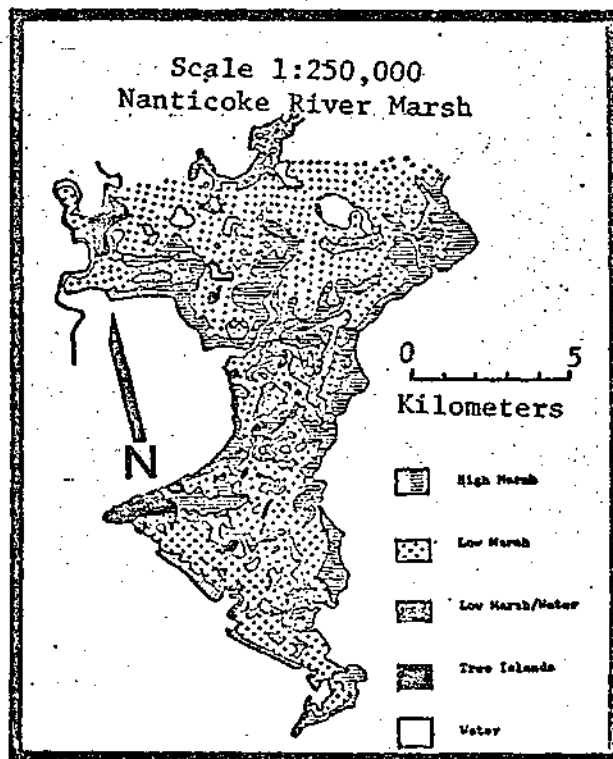


Fig. 5. 1:250,000 map of Nanticoke River marsh.

also be mapped. Smaller plant communities, occasionally less than 25 meters in diameter, can be identified. In addition, open and vegetated ditches dug for drainage or agriculture can be recognized and indicated on the map.

The Nanticoke marsh was experimentally enlarged from the 1:1,000,000 scale to approximately 1:24,000. All the boundaries seen in the other scales became blurred. It appears that unless the optics of the enlarging system are exceptionally good, this scale would only be useful for theme extractions such as upland, dry marsh, wet marsh and open water where placing of boundaries is not critical.

Aircraft Photography

Color IR aircraft photography was exceedingly useful in early analysis of ERTS-1 imagery. The scale of available photography varied from 1:4,000 (C-130) to 1:120,000 (U-2). Correlation of aerial photography and ground truth with ERTS imagery served to check the accuracy of boundary determinations and species identifications. While satellite imagery does not, at present, provide the wealth of detail shown in aerial color IR photographs, even when composites are used, the repetitive coverage and large overview make it a valuable adjunct to more conventional techniques of wetland analysis and inventory.

Conclusions

Maps made from ERTS-1 imagery showing major vegetative communities, wetland boundaries, and spoil areas serve as immediate wetland inventories as well as a data base for detection of natural or man-made changes. Successional trends can be assessed and areas of increasing human impact can be identified.

ERTS imagery has high resolution, but detailed wetland mapping is impractical at a 1:1,000,000 scale. Experimentation with enlargement and special processing shows that:

- (1) Maps at a scale of 1:250,000 are easily produced using a Bausch and Lomb Zoom Transfer Scope, projection techniques, or overlays of enlarged prints. The land-water interface and the upper-wetland boundary are generally quite well defined and gross vegetation mapping can be

accomplished at this scale.

- (2) Maps at a scale of 1:125,000 can be made by overlaying prints or projected enlargements. These maps can be made more detailed than the 1:250,000 ones and smaller vegetation units delineated.

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- (3) Enlargements to a scale of 1:24,000 causes boundaries to blur. The use of ERTS data at such a scale does not seem feasible without the use of expensive, high-performance, optical equipment.

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